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Spawning of *Decapterus macrosoma* (Bleeker, 1851) "*Galunggong*" in Tablas Island, Romblon, Philippines: with Inferences on its Reproductive Ecology and Management

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ABSTRACT

Despite its significant contribution as a cheap source of protein and support to a large fishery industry, the biology and ecology of *D. macrosoma* (Galunggong) remain poorly understood. This study investigates the spawning characteristics *vis a vis* fisheries management of *D. macrosoma* in the waters of Romblon Province. The spawning peak in Romblon Pass is during the Hot (May) and Cold (December-January) Seasons, while during Rainy (October) and Hot (May) Seasons in Tablas Strait. The timing of peak spawning of *D. macrosoma* around Tablas Island varies with that of the South Sibuyan Sea but generally similar to the breeding traits in Palawan Waters, Manila Bay, and other shortfin scads populations in Asian Waters. Initial findings argue that the variations in spawning characteristics of populations in this study are influenced by the rate of exploitation. Areas in Romblon Pass, Southwest Philippine Sea, and North Sulu Sea – show no sign of heavy exploitation. The common peak spawning months in MIMAROPA Waters are May and December, while May, October, and December in Romblon Waters. This can be used as the basis for management decisions to regulate the fishing efforts of *D. macrosoma* in the Fisheries Management Area no. 5.

Keywords: Spatial distribution, reproductive strategies, fisheries management areas

INTRODUCTION

Shortfin scad is a widespread pelagic schooling species found in coastal waters throughout most of the tropical Indo-Pacific region (Tiews et al., 1975; Ronquillo, 1974; Mundy, 2005). It is a marine reef-associated species inhabiting waters from 20 to 214m, in Tropical; 39°N - 34°S, 180°W - 180°E (Fishbase, 2020). *Decapterus macrosoma* (shortfin scads) is sometimes called long-bodied scad, locally known as *Galonggong*, and named as the peoples' fish. Aside from *D. macrosoma*, five other species of round scads can be found in the Philippine waters: *D. layang*; *D. russelli*; *D. kurroides*; *D. maruadsi*; and *D. macarellus* (Pastoral et al., 2000).

The traditional fishing grounds of round scads in the Philippines are Sulu Sea, Mindoro Strait, Visayan Sea, Moro Gulf, Lamon Bay, Cuyo Pass, Ragay Gulf, Batangas Coast, Tayabas Bay, Samar Sea, Camotes Sea, Sibuyan Sea, Bohol Sea, Davao Gulf, and Babuyan Channel, while municipal fishing grounds are areas in the Northern and Southern Mindanao, Casiguran Sound (Pastoral et al., 2000; Rada et al., 2019), and approaches of Manila Bay (Tiews et al., 1975). The Sulu area is the most productive fishing ground for round scads. The Visayan Sea ranked second, followed by the Moro Gulf (Calvelo, 1992). This study revealed that *D. macrosoma* is also fished in Romblon Pass, Tablas Strait, and Southeast of the West Philippine Sea. This species is also abundant in the Northeast of the West Philippine Sea at seawater temperature ranging from 23.5°C to 34.5°C (Pastoral et al., 2000) and avoids waters with salinity <30‰ (Tiews et al., 1975).

The shortfin scad is a typical zooplankton feeder (Tiews et al., 1975), occasionally seen in small groups along reef slopes adjacent to deep water to pursuit of zooplankton (Kuiter & Tonozuka, 2001). In some places, it seems to be especially important in the coastal waters of islands with no continental shelf and no large populations of clupeids (Roux & Conand, 2000). It matures at 17.6cm with a common length of 25.0cm TL male/unsexed (www.Fishbase. Org. 2020).

Romblon Pass is one of the highly extracted habitats and major sources of fish in the MIMAROPA Region. According to the people of Romblon, *D. macrosoma* is a commercial species locally in demand because it is a cheap source of protein and an important pelagic fish, along with sardines and anchovies, in the Philippines (Pastoral et al., 2000). It is a common food fish (Gonzales, 2000), ranking first in the production of commercial fisheries (Narido et al., 2016; DA-BFAR, 2014; Pastoral et al., 2000), and a prime commodity in the processing industry in the country (Calmorin, 2016). It is also a fresh feed to red groupers' grow-out culture in Palawan, Philippines. Despite its significant contribution as a cheap source of protein and support to a large fisheries industry, its biology and ecology remain poorly understood in Romblon and the Philippines.

Under the Sustainable Development Goals (SDG 14) on Life Below Water and Food Security, the Philippine Government initiated management protocols to control the gathering of *Sardinella lemuro* in the Southern Philippines (Rola et al., 2017). Similarly, the shortfin scads in northern Palawan are now being managed through the Philippine Department of Agriculture (DA) and the Department of Interior and Local Government (DILG) Joint Administrative Order (JAO) No. 1 (Rada et al., 2019).

OBJECTIVES OF THE STUDY

This study investigated the spawning season of *D. macrosoma* in the waters of Romblon Province. It aimed to generate knowledge as inputs and reference to sustainable harvest and management of *D. macrosoma* in the area. Specifically, this study aimed to: a.) determine the spawning seasons of *D. macrosoma* in Tablas Strait and Romblon Pass. b.) compare results to similar studies, and c.) infer the aspects of the reproductive ecology and management of the species.

MATERIALS AND METHODS

Through the Southern Tagalog Islands Research and Development Consortium (STIRDC), the Romblon State University (RSU) forged a partnership with the Western Philippines University (WPU) on a fish reproductive biology training and research writing project from May 2016 to March 2017. Out of seven, three groups: Romblon Pass, Tablas Strait, and South Sibuyan Sea groups were able to submit manuscripts for possible publication. Consequently, Rada et al. (2019) published the South Sibuyan Sea study in 2019. Hence, this paper presents the results of the remaining two studies conducted in Romblon Pass and Tablas Strait, Philippines.

Since they belonged to the same project, the methodology of this study is similar to Rada et al. (2019). The researchers bought fish samples, using purposive sampling, in identified fish landing stations in Tablas Island (Fig. 1). The fish samples were collected every first week of the month for 12 months, from June 2016 to May 2017. Five hundred fish samples were collected in Romblon Pass. A minimum of 50 samples was collected per month from landing sites of Cawayan, Long Beach, Carmen, San Agustin, Hinugusan, and Bachawan. No samples were collected in December 2016 and January 2017 due to bad weather conditions. In Tablas Strait, 943 fish samples were collected from landing sites in barangays Agpudlos, Calunacon, Poblacion, Mabini, Tanagan, and Matutuna (Fig. 1) with a minimum of 50 samples per month from June 2016 to May 2017. No sample was collected in July 2016 due to the strong southwest monsoon. The three Philippine Seasons and Climate Types used in this study followed www.silent-gardens.com (2020): Hot Season, March-May; Rainy Season, June- November; and Cold Season, December-February. Climate Types 1-4 classifies Dry and Wet Climates.

Specimens were brought to the laboratories for identification, measurements, and gonad examination. After species identification, the total length (TL), fork length (FL), and standard length (SL) were recorded in centimeters (0.1cm), while weights were measured in grams (1.0g). Upon dissecting, the color of gonads was used to determine the sex of fish samples. Male gonads whitish, while female gonads yellowish to orange. Gonads were then removed, blotted, dried, and weighed. The weight of the gonads was used to compute the Gonado Somatic Index (GSI) of (Borthakor, 2018), GSI = GW/(BW-GW) x 100. Where GSI is the Gonado Somatic index, GW is the gonad weight, and BW is the total weight with intact gonad. The average monthly GSI was determined to determine the peak spawning month(s) of *D. macrosoma*.

The length at maturity was obtained following the macroscopic descriptions of the various reproductive phases and calculated using the percentage of mature and spent individuals divided by the total number of samples and applied to the logistic curve of King (1995). Only female samples were used in the analysis of the length of sexual maturity. The gonads were then preserved in 10% formaldehyde for further analysis. In every field sampling, the fishermen were made to mark their fishing ground on a prescribed map (Fig. 1).

RESULTS AND DISCUSSION

Spawning Season

The results suggest that *D. macrosoma* around Tablas Island has two spawning peaks in a year. In Romblon Pass, the ripe gonads are evident from April to June (Fig. 2), GSI reaching the peak in May. Although no fish samples were collected in December 2016 and January 2017, an increasing trend of GSI value is observed between these months (Fig. 2). Hence *D. macrosoma* in Romblon Pass may have two annual spawning peaks, from December to February and April to June, with the highest peaks in December-January and May. There are also two spawning peaks in Tablas Strait, during October and May (Fig. 3). In Romblon Pass, spawning occurs during the Hot and Cold Seasons. While in Tablas Strait, the highest spawning activity is during the Rainy and Hot Seasons. Ring-net fishers in the northeast of Palawan observe several gravid individual shortfin scads throughout the year, indicating that the species may spawn all year round.

As such, *D. macrosoma* may spawn throughout the year with two high reproductive activity peaks. Both Tablas Strait and Romblon Pass have the same spawning peaks during the Hot Season (May), while the second peak of Romblon Pass is delayed by two months (December, Cold Season) compared to Tablas Strait. Generally, *D. macrosoma* breeding activities are high all year round, happening in different areas at different seasons (Fig. 4). The timing of the peak spawning season of *D. macrosoma* in Tablas Island is unique to the adjacent South Sibuyan Sea, occurring in February (Cold Season) and August (Rainy Season) (Rada et al. 2019). Tiews et al. (1975) reported a similar case that the breeding period of *D. macrosoma* and *D. russelli* is extended from November to March in Palawan Waters, while delayed in the approaches of Manila Bay by one-two months. The spawning attributes of *D. macrosoma* outside the Philippine Waters are generally similar to those in the Philippines (Table 1). These emphasize that

D. macrosoma's reproductive timing agrees with the other tropical marine fishes of which, according to Lowe-MacConnell (1979, 1987) and Longhurst and Pauly (1987), vary by species – spawning throughout the year or having well-defined breeding seasons. Even throughout the year group, there are often clear seasonal variations in the proportion of fish in a population that are reproductively active (Wootton, 1990).

Some mechanisms may control the timing of gonad maturation, like the harshness and variability of the abiotic environment, the availability of food to the parental fish and on the offspring, and the nature of the habitat of the parental fish (Wootton, 1990). Hence, the variation of reproductive timing of *D. macrosoma* populations within the waters of Romblon and its adjacent seas may be attributed to the above-mentioned factors. The Sulu Sea and the waters of Romblon have high spawning activities throughout the year (Fig. 4). The most common peak spawning month in MIMAROPA Waters are May and December, while May, October, and December in Romblon Waters. This information (Fig. 5 and Fig. 4) could be useful for management decisions, especially on close fishing season or areas of *D. macrosoma* in Romblon Province and the MIMAROPA Region (Fisheries Management Area no. 5).

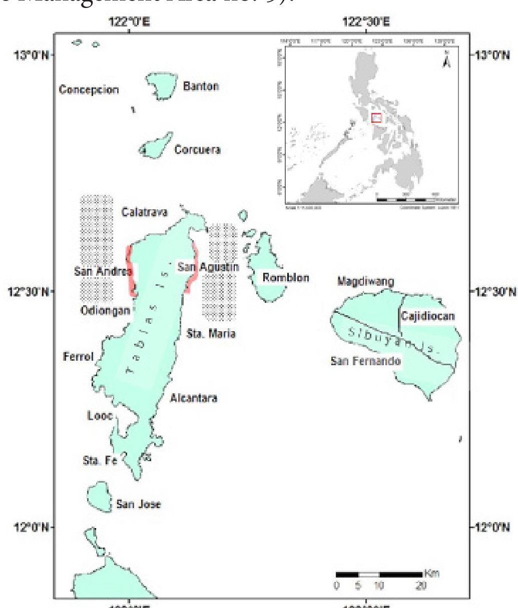

Figure 1. Map of Romblon, Philippines, showing the sampling stations (red shade) and the indicative fishing grounds (dotted shade) of shortfin scad in this study. Map created by the 2nd author.

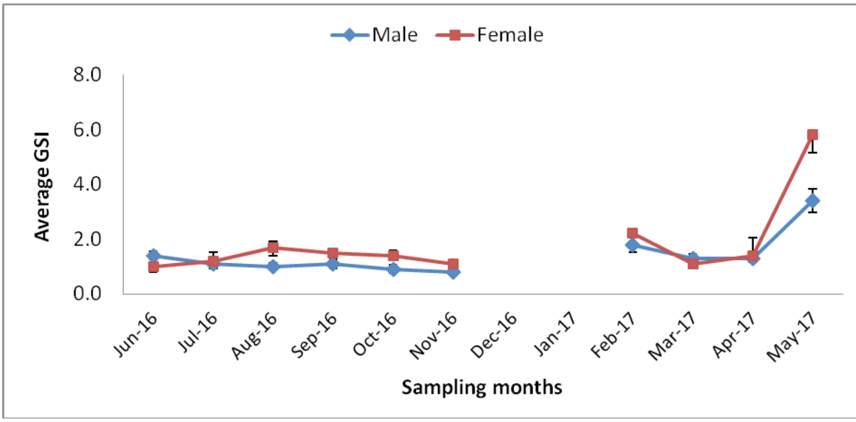

Figure 2. Average monthly GSI of *D. macrosoma* caught in the waters of San Agustin Municipality, eastern Tablas Island (Romblon Pass), Philippines from June 2016 to May 2017.

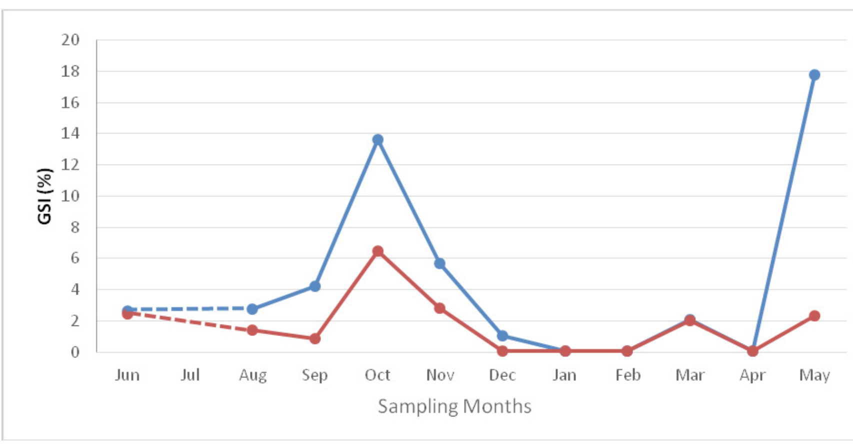

Figure 3. Average monthly GSI of *D. macrosoma* caught in the waters of the Municipality of San Andres Municipality, western Tablas Island (Tablas Strait), Philippines from June 2016 to May 2017.

Table 1

Aspects of the reproductive ecology of D. macrosoma in the Philippines and Asian Waters (ND=No Data)

Country/Location	Spawning peak months	Length at maturity (cm)		Ave. Length/ Range (TL cm)	Fishing Grounds	Source
		Male	Female			
Philippines						
Tablas Strait	May & Oct.	24.36	20.36	16.43	West of Tablas Island	This study
Romblon Pass	May; Dec.-Jan.	ND	ND	20.28	East of Tablas Island	This study
South Sibuyan Sea	Feb.; Aug. - Dec.	17.22	15.29	16.52	Southwest Sibuyan Island	Rada et al. 2019
Sulu Sea	May-Aug.; Nov.-Feb.	ND	18.3	16.37	Northeast of Palawan Island	Candelario et al. in prep.
Sulu Sea	Sep.-Dec.; Apr -Jul	ND	18.3	13.17	Southeast of Palawan Island	Candelario et al. in prep.
Mindoro Strait	ND	ND	ND	9.5-10.5	West of Mindoro Island	Pastoral et al, 2000
North West Philippine Sea	ND	ND	ND	7.0-24.0	Waters of Ilocos Sur	Pastoral et al. 2000
North West Philippine Sea	ND	ND	ND	8.5-17.0	Waters of Subic Bay	Pastoral et al. 2000
South West Philippine Sea	Dec. to Mar.	26.0	24.0	17.0	West of Palawan Island	Palla et al. 2018
Philippines	Nov. to Mar.	18.0-20.0	18.0-20.0	17.75 male; 17.60 female	Palawan Waters	Tiews et al. 1975
Philippines	Nov. to May	18.0-20.0	18.0-20.0	17.75 male; 17.60 female	Approach to Manila Bay	Tiews et al. 1975
Asian Seas						
China Sea	May –Jul.	ND	ND	ND	East China Sea	Kishida 1986
Japan	May to Aug.	22.6 (FL)	23.8 (FL)	ND	Southern Kyushu	Shiraishi et al. 2010
Indonesia	Jul/Aug.	14.8	15.5	ND	Java Sea	Widodo, et al. 1991
Indonesia	ND	ND	ND	21.16	Ambon Island,	Pattikawa et al. 2017
Indonesia	ND	ND	17.7 (FL)	ND	Malacca Strait	Tampobulan & Merta 1987
Thailand	Feb.-Apr.	ND	17.20 (FL)	ND	Malacca Strait	Sutthakorn & Saranakomkul 1987

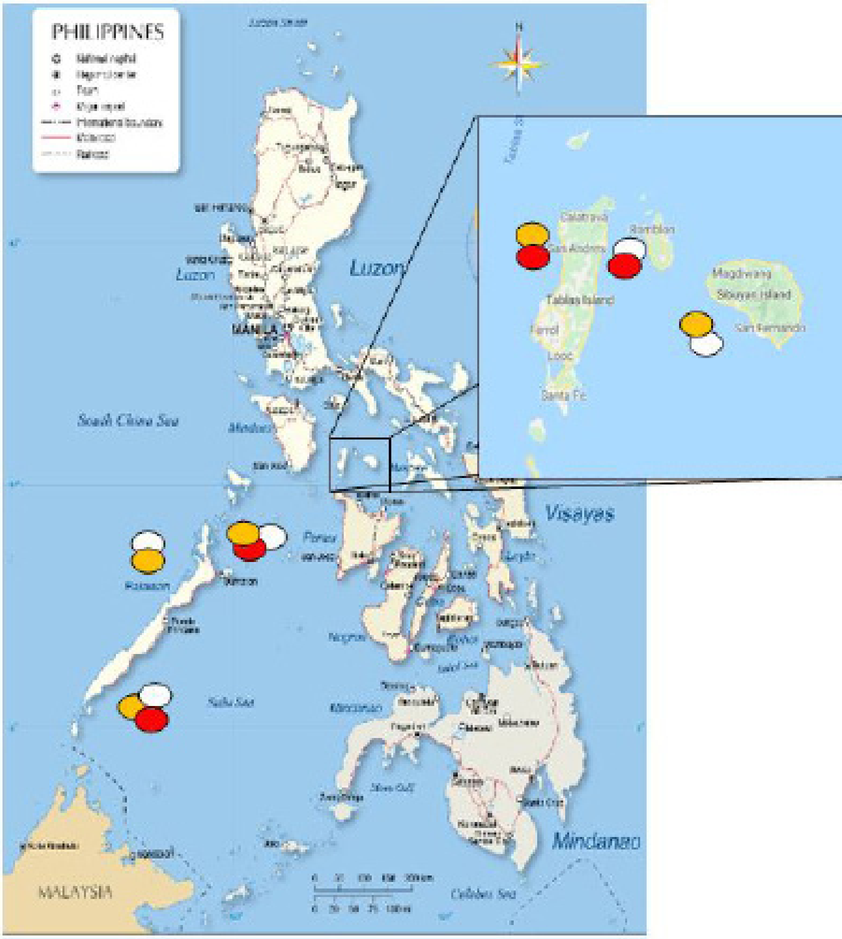

Figure 4. Seasonal spawning map of D. macrosoma in the waters of MIMAROPA Region, Philippines. Hot Season (red circle), March-May; Rainy Season (brown circle), June- November; and Cold Season (white circle), December-February. (Source of map: www.google.com. en.wikipedia.org.)

The reproductive seasonal timing of *D. macrosoma* in Tablas Strait and Romblon Pass occurred in Hot Season, when the temperature was relatively high preceding the Rainy Season when biological productivity of nearshore waters is supposed to be relatively high, due to more nutrient runoffs from adjacent lands, whereby producing planktons that serve as food to larval fishes spawned during the Hot Season. According to Wootton (1990), a fish should reproduce at the time of the year that will tend to maximize its lifetime production of offspring. The larval fish must hatch into the world that can provide appropriate food, protection from predators, and benign abiotic conditions, while the eggs are laid in shallow backwaters or littoral areas where water temperatures increase quickly as the air temperature increases. This kind of timing in the reproduction of *D. macrosoma* is also observed in the Sulu and West Philippines Seas (Fig. 4), Philippines, and its neighboring seas – Southern Kyushu, Japan; East China Sea; Malacca Strait, Thailand (Table 1).

Many coral reef fishes that have pelagic larvae spawn in the evening (Helfman 1986), to reduce predation on the eggs because of the low light levels and because of the numbers of predators feeding on zooplankton are reduced at that time of the day (Wootton, 1990). The fish makes spawning runs soon after the highest daily tide, 2-4days after both the new and full moon phases (Moffat & Thomson, 1978). The heaviest runs occur near the time of the new and full moons and ensure the dispersal of the eggs away from the reefs on the ebbing tide (Wootton, 1990). Judging from above, *D. macrosoma* would most likely spawn in the evening during the highest daily tide after few days of new moon and full moon at deep slopes of the nearby shallow coral reefs. A follow-up in-depth study on the diel and moon phase spawning traits of shortfin scads in Philippine waters can shed more light on this hypothesis.

Length at maturity

The length at maturity of *D. macrosoma* in Tablas Strait is 20.36 cm in females and 24.36 cm in males (Table 1), larger than that of the South Sibuyan Sea – 15.29 cm in females and 17.22 cm in males and the eastern coast of the Palawan Island, 18.3 cm in females. However, the *D. macrosoma* population at the South of West Philippine Sea has a larger length at maturity than Tablas Strait, 26.0 cm in males, and 24.0 cm in females, while Fishbase (2020) records mature length of *D. macrosoma* at 17.60 cm. Moreover, the first maturity of *D. macrosoma* in Tablas Strait is larger than those of the neighboring Asian Waters' populations, except the Southern Kyushu, Japan (Table 1).

The age at maturity within a species may vary (Wootton, 1990). Similar inter-population variation is found in many other species, which is partly reflected by genetic differences, wherein fish from different populations reared under similar conditions show differences in their age and size at maturation (Alm, 1959). However, part of the variation also reflects proximate environmental effects on the age (size) at maturity depending on the effects of the change on the growth and mortality rates (Wootton, 1990). For example, age at first maturity for the American Plaice population declined due to heavy fishing pressure that reduced the abundance of the plaice. Being less abundant, the growth rate tended to increase probably because there was more food for the surviving plaice (Wootton, 1990). Fish receiving a higher food ration becomes sexually mature earlier (Hay et al., 1988; Wootton, 1973; Bagenal, 1969), while fish that matures late is believed to have an abundant population compared to fish with reduced size at maturity. As such, the larger lengths at maturity of *D. macrosoma* in Tablas Strait and South of West Philippine Sea (Palla et al., in prep) suggest that these populations are more abundant than other shortfin populations mentioned in this study. And vice versa in populations with smaller lengths at maturity (Table 1), hence should be considered in management strategies.

Average Length

The lengths of fish samples in Romblon Pass are 18.3-23.0cm, with a 20.28cm mean size (Table 1). In Tablas Strait, the lengths of the large fish samples range from 23.6cm-24.5cm, while the smaller fish samples from 11.6cm-12.5cm; the mean length of all samples is 16.43±2.6cm. In the Philippine Seas, the largest average sample size of the *D. macrosoma* population is 20.3cm in Romblon Pass, the smallest in the southwest Sulu Sea and Mindoro Strait, 13.2cm and 9.5-10.5cm, respectively, while the rest of the locations range between 16.0cm to 18.0cm. A 21.16cm average length was reported in Indonesia (Table 1), while www.Fishbase.Org. (2020) records the common length of *D. macrosoma* at 25.0cm TL male/unsexed.

Most life-history traits are correlated with size, which acts as a constraint on metabolic rates and energy assimilation, so influencing the entire lives of animals, including their growth, reproduction, survival (Reiss, 1989), and maintenance of the sustainability of the population (Chen et al., 2018). For example, the larger individuals tend to produce more and better eggs (Hseih et al., 2010; Hixon et al., 2014) and have longer spawning season (Berkeley & Houde, 1978; Hutchings & Myers, 1993; Lambert, 1987; Sogard et al., 2008). Traditional single-species assessment models account for the reduction in mean size caused by increasing exploitation rate (Beverton & Holt, 1957). In an exploited fish stock, the size structure/distribution is predicted to shift towards small individuals caused by size-selective fishing and/or warming (Chen et al., 2018). Temperature tolerance in fish can bring changes in fish size, age, and seasonality. The effect of temperature on the rate of metabolism has an important consequence for the egg stage of the fish's life history (Wootton, 1990), for example, the time between spawning and hatching of a dragonet, *Repumucenus huguinini*, has increased from18h at 24.8°C-26.6°C to 23h at 21.5°C-21.8°C (Gonzales et al., 1996) and the threespine stickleback from about 6days at 25°C to about 40days at 8.0°C (Wootton, 1976). Hence, the reduced average size of the stock could be a result of overexploited stocks and or an increase in seawater temperature. The former removes the number of large parental individuals from the stock, while the latter increases the metabolism of the fish, leading to faster growth and size at maturation. Hence, it becomes possible that fishing grounds with smaller size maturity and average size (South Sulu Sea and South Sibuyan Sea) (Table 1) are more exploited and or affected by temperature rise.

The proportion of mature fish at age or length is one of the most important population attributes in assessing reproductive potential. This proportion is usually named the maturity ogive, while GSI is a common method of describing the relative size of the gonads (Wootton, 1990; Flores et al., 2014) used it as an alternative way to estimate the maturity ogives. The GSI formula (GSI = GW/(BW-GW) x 100) (Borthakur, 2018) presents the proportion of the gonad weight relative to the bodyweight of the fish. The heavier the gonad, the higher the GSI value. The GSI value in Tablas Strait is far higher than that of the Romblon Pass and South Sibuyan Sea, hence, assumed to produce more and better quality eggs (studies on fecundity can further support this information). Higher GSI value, larger length/size at maturity, and the average length of the fish population indicate that the *D. macrosoma* population in Tablas Strait could be a primary spawning guild in the waters of Romblon that should be managed properly.

Since Romblon Waters and the southern Sulu Sea have the same climate (Type 3) that are characterized by a short dry season from December to February (silent-gardens, 2020), although both tended to peak in three seasons, they have varied conditions in size compositions and lengths at maturity (Table 1). On the other hand, the West Philippines Sea, northern Sulu Sea, and Mindoro Strait also belong to another climate (Type 1) characterized by two pronounced seasons, dry (November to April) and wet during rest of the year, do not have the same spawning seasons (Fig. 4), while Mindoro Strait has a very small average size.

Gonad maturation, reproductive timing, length at maturity, and size structure are controlled by the environment (climate, habitat, etc.), genes, and exploitation rate (Chen et al., 2018; Wootton, 1990; Alm, 1959; Beverton & Holt, 1957). Although the *D. macrosoma* in the South Sulu Sea and Romblon Waters, and North Sulu and West Philippine Seas belong to the same climate, respectively, and due to proximity, they may belong to the same gene pool (except the West Philippine Sea); it is most plausible that the main cause of variations in their spawning character traits is the rate of exploitation rather than genetics and environment. Hence, it can be deduced that populations in areas of Romblon Pass, Southwest Philippine Sea, and North Sulu Sea, having a larger length at maturity and average lengths, and higher GSI value, show no sign of heavy exploitation (Table 1 and Fig. 4), while populations in the areas of South Sulu Sea, Mindoro Strait, and South Sibuyan Sea manifest signs of exploitation. Studies on fish harvest and population genetic in these populations will further support these initial findings.

Fishing Grounds and Gears

In Romblon Pass, fish samples were caught in the coastal waters between the Island of Romblon and Northeastern Tablas Island, while the fishing grounds in Tablas Strait is located at the northwest portion of Tablas Island (Fig.1). The fishing grounds in Tablas Island have combined shallow-water reefs, deep slope areas, and canals known to be inhabited and serve as a migratory path of a variety of fishes including *D. macrosoma*. The fishing depth is between 100-300m, usually at 30-50m waters in Tablas Strait with an estimated distance of 1.5 to 3.0km from the shoreline of Tablas Island. In Romblon Pass, *D. macrosoma* fishing grounds are located within 180-200m water depth, while Fishbase (2020) recorded 20 to 214m depth, usually 30 - 70m for *D. macrosoma* fishing ground. Tiews et al. (1975) reported the depth of the fishing grounds in Palawan waters and areas approaching Manila Bay to be 37-183m. In this study, the fishing depth range of *D. macrosoma* is 20-300m.

Drift gillnet (largarete) and ring-net (pangulong) were used to catch *D. macrosoma* in Tablas Island, usually set from night till morning (6:00 pm-4:00 am). The ring-net operates by encircling a school of fish and impounding them by closing the rings at the bottom of the net like a purse (Gonzales, 2018). The drift gillnet uses 9-10knots or 3.4-3.8 cm mesh-size multifilament nets, operated by one-two persons. Species caught are small pelagic species, including small tunas. Besides, the smaller baby ring-nets use outrigger boats powered by a 10-16hp inboard engine, operated by 3-10 fishermen at 30-50m waters in Tablas Strait.

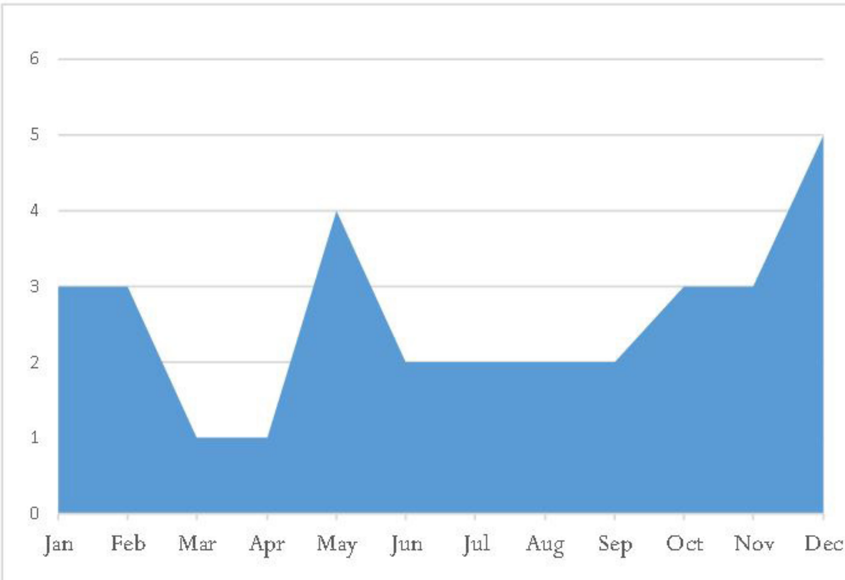

Figure 5. Summary of *D. macrosoma's* peak spawning months across the waters of the MIMAROPA Region, Philippines.

CONCLUSIONS

The shortfin scads in around Tablas Island have two spawning peaks in a year: in Romblon Pass, Hot Season in May, while another spawning peak is assumed to occur during Cold Season (December-January). In Tablas Strait, the spawning peaks are during the Rainy (October) and Hot (May) Seasons. The spawning period of *D. macrosoma* in Tablas Island is unique to that of the adjacent South Sibuyan Sea. The spawning of *D. macrosoma* in Tablas Island is similar to the breeding period of *D. macrosoma* and *D. russelli* which is extended in Palawan Waters, while delayed in the approaches of Manila Bay. Furthermore, spawning strategies of *D. macrosoma* in the Philippines are more or less similar to populations in other Asian Waters. The most common peak spawning month in MIMAROPA Waters are May and December, while May, October, and December in Romblon Waters.

With relatively larger GSI value, length/size at maturity and average length suggest that the *D. macrosoma* population in Tablas Strait may be a primary spawning guild in the waters of Romblon. While areas in Romblon Pass, Southwest Philippine Sea, and North Sulu Sea show no sign of heavy exploitation, however, *D. macrosoma* populations in the areas of South Sulu Sea, Mindoro Strait, and South Sibuyan Sea are manifesting signs of exploitation.

RECOMMENDATIONS

The seasonal spawning map and information on common peak spawning months can be used as the basis for management decisions to regulate the fishing effort of *D. macrosoma* in the waters of Romblon Province and the MIMAROPA Region (FMA5). On-wards studies on the spawning of *D. macrosoma* should include fecundity, average length, length at maturity, sex ratio, condition factor, size-based indicators, temperature salinity, growth, productivity, spawning period, fish harvest, etc. so that we can use more indicators to assess and compare the situations across fish populations. Population genetic studies would also be helpful to discern possible genetic variations among populations or sub-populations.

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